

# DEVELOPING ALTERNATIVE TRANSPORTATION IN OLD WORTHINGTON

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## **1. Executive Summary**

The following report covers the research and development of alternative transportation in the Old Worthington commercial district. This was in response to the proposal sent by the City of Worthington, who wanted goals developed to create a more sustainable commercial district. Incorporation of Smart Growth principles narrowed the scope of the project to focus on alternative transportation infrastructure. Two research objectives were created as a result of this, with a third objective ultimately being dropped due to issues with scope and data analysis. These objectives are as follows:

- Exploring the costs and benefits of an electric vehicle charging station in Old Worthington
- Finding ways to increase bicycle usage in Worthington and improve the accessibility of the Olentangy River Trail to and from Old Worthington

Research for both objectives included communication with Worthington citizens and collaboration with city officials. Businesses and private organizations were consulted to gain information and find a sense of direction. Once research was completed, cost-benefit analysis was conducted in order to determine any potential economic barriers, as well as social benefits that might be hard to quantify. Further results can be found for each objective in their respective sections, as well as in the appendices with the corresponding tables and figures. The low cost and potential positive cash flows from the EV charging station in Old Worthington makes for an effective option. The bike path infrastructure has a higher cost that may be able to be offset through subsidies such as the Recreational Trails grant from Ohio Department of Natural Resources. Also, return on investment is difficult to calculate, considering the monetary return would be calculated through increases in traffic to local businesses. Recommendations include:

- Installation of a Level 2 electric vehicle charging station in the parking lot north of New England Street and West of High Street, as well as increased education and outreach initiatives for electric vehicles
- Renovation of the path leading from Olentangy Trail towards the commercial district including wayfinding signage, as well as long-term bike infrastructure planning

Another key aspect of the project included adding bus stop infrastructure to four bus stops near the downtown area. This goal was dropped due to insufficient research and available time, although a few general recommendations were included.

## **2. Introduction**

This report addresses the first proposal put out by the City of Worthington, which was developing sustainability goals for the Old Worthington commercial district using Smart Growth principles. While all of the principles were taken into account, the objectives that were created center around the principles of providing a variety of transportation choices, strengthening development in an existing community, and fostering an attractive community with a strong sense of place (Smart Growth 2016). While there are a number of options that could have been evaluated, we chose, in consultation with our advisors, to research the following:

- Install a Level 2 electric vehicle charging station in the parking lot north of New England Street and West of High Street
- Renovate path leading from Olentangy Trail and add bike routes and historic district information to Worthington's wayfinding program

The motivation behind these objectives was to promote strong, sustainable progress in the Old Worthington commercial district by improving existing infrastructure and expanding viable transportation options. They aim to create balance between economic viability, quality of life improvements, and long term environmental sustainability in Old Worthington. Through rigorous research, analysis, and collaboration, it has been found that there is great opportunity for implementation of both of these objectives. For Objective 1, it is recommended that an electric vehicle charging station be installed in the commercial district, along with the creation of education and outreach initiatives for electric vehicles. For Objective 2, it is recommended that the city adds wayfinding signage and renovates key areas of the Olentangy Trail leading to Old Worthington. A third objective regarding bus stop infrastructure was explored but due to issues with scope and data analysis, we provide only a few general recommendations.

## **3. Objective 1: Electric Vehicle Charging Station**

### **3.1 Research Steps, Methods, & Data Collected**

Various resources were utilized in the information and data gathering process. In person meetings with employees of Clean Fuels Ohio and Ohio EV Solutions provided foundational resources, along with recommendations on electric vehicle charging infrastructure. In addition, they provided insight into education and outreach initiatives. Online research was

conducted for a large quantity of information contained in this report. A multitude of governmental reports, particularly from the U.S. Department of Energy and Energy Information Administration, were used to understand electric vehicle and energy use throughout the country. Scholarly reports from research organizations, such as the National Renewable Energy Laboratory, MIT, and others, along with the private firm, ChargePoint, were utilized for further background information on environmental and economic impacts of electric vehicles. Columbus' Smart City Vulcan Grant application was used as an information source and for recommendations. A net present value was conducted to calculate investment recovery of differing scenarios depending on total installation costs of the EV charging station, hours of use, and rate charged to consumer. Phone and email outreach was used to garner more complementary data on possible partners, funding programs, and use from across the industry. Finally, results from a survey of Worthington residents pertaining to electric vehicles and charging infrastructure was applied to overall findings and recommendations.

### *3.1.1 Electric Vehicle Background*

Plug-in electric vehicles (PEVs) include full battery electric vehicles (BEVs), such as the Nissan Leaf, and plug-in electric hybrid (PHEVs), like the Chevrolet Volt. The former is completely run by its battery that can be charged from a variety of public or private charging stations. The latter contains a mixture of a chargeable battery for short distances, and a gasoline-engine to be used in situations where the battery has run out of stored energy. Both types of vehicles can be charged through three types of stations, also known as electric vehicle supply equipment (EVSE): level 1, 2, and 3 (DC fast-charging). Level 1 uses a 120-volt AC charger, and it is most commonly used at home for overnight charging and provides 2 to 5 miles of range per hour of charge time. Level 2 uses a 240-volt system that provides up to 25 miles of range per hour. DC fast-charging can give 60-80 miles per 20 minutes using a 480V system, but this is significantly more expensive to purchase, install, and use. Level 2 is currently the most common among public stations, with the vast majority of charging ports utilizing the SAE J1772 connector (DOE 2012).

Electric vehicles provide benefits over traditional petroleum powered vehicles in a variety of ways. They tend to have lower life cycle greenhouse gas emissions, cheaper lifetime maintenance costs, and offsetting of the nation's oil demand (75% of which is from the

transportation sector), which helps enhance U.S. energy security. **Figure A.1.1** is a tool developed by MIT that plots lifecycle greenhouse gas emissions against total lifetime vehicle costs (vehicle, fuel, maintenance). It typically shows plug in electric vehicles being lower in both cost and emissions than internal combustion engine vehicles (MIT 2016).

### 3.2 Data Analysis and Findings

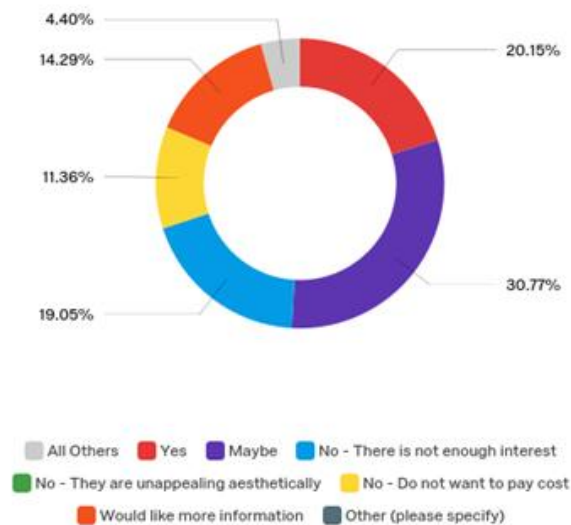
While PEVs are not a perfect solution for every individual and their needs, education and outreach can be used to inform people on commonly held myths. These include range anxiety, affordability, and access to charging infrastructure. Most current BEVs are not ideal for traveling long distances; however, an MIT study estimates that 90% of driving needs can be met with today's current fleet of electric vehicles (Chandler 2016). As for affordability, given the current governmental \$2500-\$7500 tax rebate, PEVs can be similarly priced with comparably sized internal combustion engines. Additionally, there is a stigma that full battery electric vehicles do not have the "power" to meet their needs. Solutions to overcome this fear are elaborated on later.

As noted in multiple responses from the Worthington survey, some individuals do not believe there are emissions benefits from using PEVs due to Ohio's lack of renewable energy adoption. West Virginia University, supported by data from the US DOE, calculated this to not be the case. **Figure A.1.2** shows that conventional gasoline vehicles produce nearly 35% more emissions in CO<sub>2</sub> equivalent per annum in the Columbus area (Maves & Brenner 2012). Part of the Clean Cities grant will see Columbus actively educating citizens to reach their target of 8,000 individuals engaged through EV programs by 2018, further increasing chances of public purchase and adoption across the Columbus metropolitan region (SCC RFP 2016). Finally, in the Worthington survey, the question asking, "Would you like to see more charging stations for plug-in electric vehicles in Worthington?" yielded mixed results. Of 311 responses, 20% chose outright yes, while another 45% responded with "maybe" or "would like more information." 36% featured a variation of the three "no" options (**Figure 1**). While exact data on the number of electric vehicles in the Columbus region is difficult to find, as of 2016, Ohio had over 6800 registered electric vehicles (Smith 2016). This number will surely grow, as nationwide EV sales have continued to expand each year over the last decade, with the exception of 2015. The Energy Information Administration reports that by 2025, 6% of US

vehicle sales will be plug-in electric vehicles (EIA 2016). More specific to this region, one of the stated goals of the Clean Cities Grant was to introduce at least 2,000 privately owned electric vehicles to the Columbus area by 2018, greatly increasing the number of individuals that will be able to utilize public charging infrastructure (SCC RFP 2016).

**Figure 1 – Worthington Resident Survey Response**

Would you like to see more public charging stations for plug-in electric vehicles in Worthington?



Source: The Ohio State University ENR 4597 Qualtrics Survey

Description: The distribution of responses to the posed question from over 300 Worthington residents that participated in the online survey

There are multiple websites and application tools, such as PlugShare, ChargePoint, and the Alternative Fuels Data Center (AFDC) station locator, that display every installed EVSE. Where to locate these tools is listed in Appendix 3. As shown in the PlugShare EV map in **Figure A.1.3**, while there are many units in Dublin, Easton, and Central Columbus, there is a large gap in the Worthington area. Additionally, due to EV users' desire to charge their vehicles, there is evidence that they stay in areas with charging stations for a longer period of time. A case study of a retail store's six charging stations saw that PEV drivers kept their vehicles parked for 72 minutes, which is 50 minutes longer than that store's previous average dwell time (ChargePoint 2016). This gives potential for more time spent in downtown Worthington by these individuals and the possibility of spending more money at local businesses.

While one electric vehicle charging station is not solely responsible for environmental change, it encourages adoption of a technology that is a more sustainable option than the status quo. As stated in the Columbus Smart Cities grant, “lack of access to charging infrastructure is the most significant barrier to consumer adoption of electric vehicles” (SCC RFP 2016). Even with much of our electricity being produced by coal, studies show that electric vehicles still produce fewer emissions than internal combustion engine vehicles (**Figure A.1.1 & A.1.2**). In addition, a Department of Energy report on the greenhouse gas abatement for subsidized commuting options at the workplace shows level 2 stations to be cheaper per metric ton of abatement than both transit and vanpool subsidies, and only slightly more expensive than bike subsidies (**Figure A.1.4**).

Lastly, the addition of electric vehicles will offset local pollution from internal combustion engine vehicles, leading to enhanced public health in Worthington (DOE 2012).

The highest costs to Worthington will be the price for the electric vehicle supply equipment and its installation. EVSE costs will range anywhere from \$500 for the most basic of options to over \$10,000. For a public municipality such as Worthington, it is most common to use a Level 2 hookup that utilizes 240 volts at roughly 30 amps (DOE 2012). Other variables, such as number of charging ports, aesthetics, length of cord, and network capabilities (among others) will all affect the price of a unit.

Aerovironment offers a basic single port option for \$1870 (EVSolutions 2016). These types of units, which are simply plug and charge, do not offer a way for the consumer to pay for what they use. In order for Worthington to receive any sort of monetary return from this type of unit, a parking meter would need to be placed at the parking spot. On the other hand, companies such as ChargePoint operate network stations that, though more expensive, offer greater benefits. Called *smart chargers*, they provide information on station availability to users, manage parking and user behavior, track energy usage and costs, and provide remote support for features like variable price setting (ChargePoint 2016). The CT4011, a single port level 2 from ChargePoint, will run around \$5,010 (Amazon 2016).



Installation costs are most variable depending on location. The distance from an electrical panel and the amount of trenching and conduit are two of these variables. Locations for installation estimates were picked by proximity to these panels in order to mitigate costs. Ohio EV Solutions performed a pricing quote for two locations: the parking lot of the Worthington Library and the parking lot north of New England Street and West of High Street (**Figure 4**).

The cost of electricity for the City of Worthington is \$.09/kWh (Worthington 2015). This cost could be offset depending on how the city decides to charge consumers for usage. The Department of Energy points out that waypoint and identification signage is very important for electric vehicle charging infrastructure optimization (DOE 2015). Using their calculations, five signs would be needed, costing roughly \$25 each (ComplianceSigns 2016). Additionally, the Department of Energy reports very low maintenance costs for most charging stations, estimating \$25-\$50 annually (DOE 2016). Taking the average maintenance cost plus the cost of signage, total expenses for the first year would be around \$158.50, with \$25-\$50 repeating annually. As Worthington does make some wayfinding signage in-house, some of these costs may be higher than actual values. Additionally, smart chargers require a recurring network fee of \$240 yearly.

### *3.2.1 Investment Recovery*

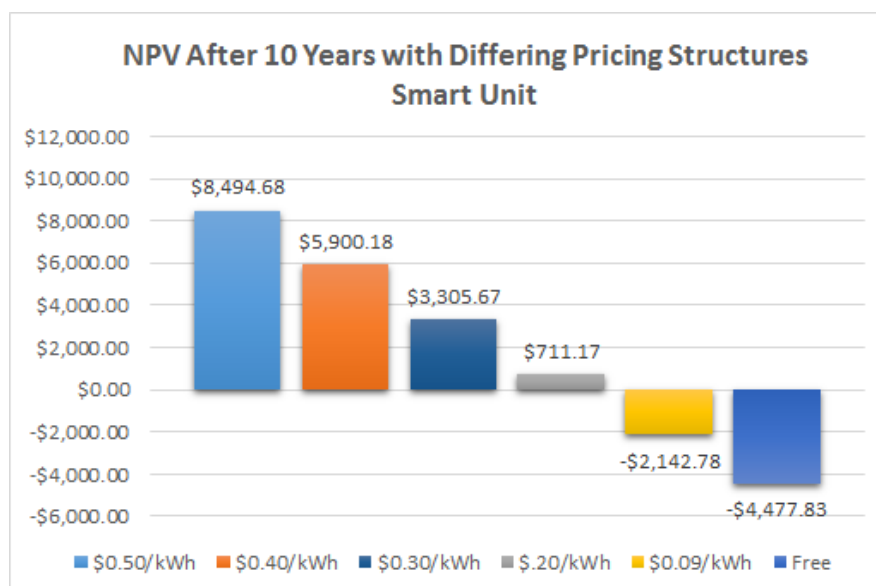
Worthington can choose a variety of pricing structures to charge consumers to access the ports. Depending on the price set, Worthington can maintain the cost of electricity to run the unit and the yearly maintenance cost while starting to recover some of its initial investment. Whether the city chooses a “smart” or “dumb” unit will also greatly affect the initial investment cost and recovery. The level 3 charging station at the AAA in north Worthington sees roughly 20 charges per month. This was used as the baseline, along with a series of other assumptions in order to estimate revenue garnered from usage for different pricing models. For both types of EVSE, revenue was calculated by subtracting yearly costs from the income garnered from paying consumers. These incomes were then extrapolated across 10 years with a 5% discount rate to calculate the current net present value of the investment. A full breakdown of these assumptions used to formulate the revenue can be found in the Appendix (**Table A.1.1**).

### 3.2.2 Findings

The cost of installation was quoted by Ohio EV Solutions for the library and the public parking lot. They estimated this to be \$4,000 and \$2,000, respectfully. Thus, the total price for installation (including unit, installation, and signage cost) of the ChargePoint 4011 in the parking lot is \$7,135. The Aerovironment RS at this location would cost \$4,620. This also includes the price of a meter, estimated at \$615, which needs to be present in order for Worthington to garner revenue (Gano 2016). The total costs for both the single and dual port versions of these stations at both locations can be found in the Appendix (**Figure A.1.7**).

If the City of Worthington installs a smart station, and charges consumers \$0.50 per kWh to utilize the unit's service, the net present value of this investment after 10 years would be \$8,494. This is enough to cover the library installation cost by over \$1000 in its lifetime. Conversely, if the city priced "charging" at the cost of electricity (\$.09/kWh), the net present value would be negative \$2,142 over these 10 years. On the other hand, if the Aerovironment with the parking meter is chosen and the spot is rated at \$3 per hour, Worthington would earn \$8,500 over this period, nearly doubling its investment. If they were to offer this type of unit as a public service and not charge for use, there would be NPV loss of \$289.57 over the 10 years. A full breakdown of the net present value calculations for both types of EVSE are shown in **Figures 2 and 3**.

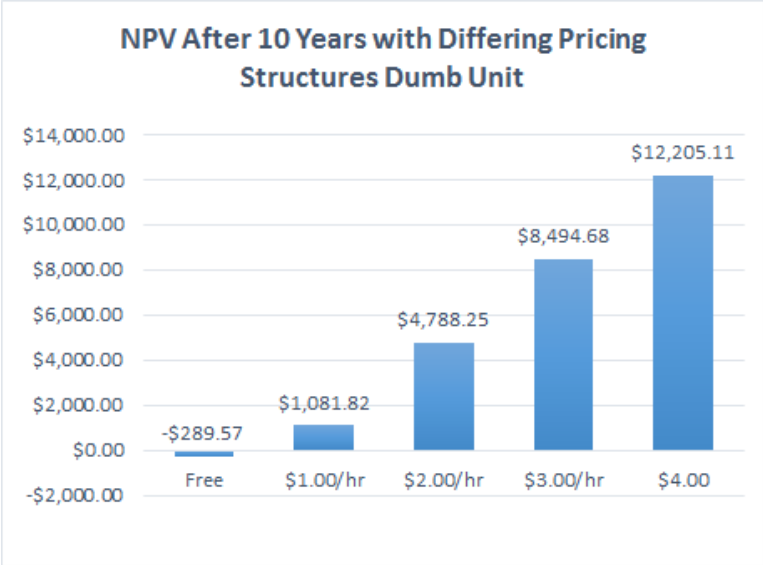
**Figure 2: Net Present Value of Smart Station**



Source: Various information sources (see Assumptions). Calculated by Connor Herman

Description: Net present value performed using a 10-year cycle and 5% discount rate at various price points per kWh for the smart unit.

**Figure 3: Net Present Value of Dumb Station**



Source: Various information sources (see Assumptions). Calculated by Connor Herman  
Description: Net present value performed using a 10 year cycle and 5% discount rate at various price points per hour for the “dumb” unit.

**3.3 Recommendations**

**3.3.1 Charging Station Installation**

It is recommended that Worthington install a Level 2 electric vehicle charging station in the parking lot north of New England Street and West of High Street. This location is marked in **Figure 4**. The ChargePoint 4011 or a similar single port smart charging station is recommended. The price is to be set at \$0.50 per kWh. While a “dumb” charger can work, the only way the city can recover some of the associated costs is through placing a traditional meter on the parking spot. This option will have a lower front end cost and potential for higher straight monetary return, but there are other benefits to being on a network station, such as feasibility, data collection, recognition, and variable price setting that cannot be accomplished with a dumb unit. To maximize usage, roughly five signs should also be placed on High Street and streets surrounding the charging unit to highlight its location.

An added benefit of laying the groundwork to install one charging unit means that the most expensive part of increasing charging infrastructure is completed. Adding a second unit or upgrading to meet future demand will be much cheaper, with the only expense coming from

unit cost. Many individuals from across the state and nation will have the opportunity to see Worthington's charging station, which could increase traffic to the area and set Worthington as a "green leader." Additionally, as noted earlier by the increasing sales of electric vehicles, Worthington can prepare for the future demand by proactively getting the necessary infrastructure to meet these demands.

### *3.3.2 Education and Outreach Initiatives*

While the survey results show there is some support for adding charging infrastructure (around 50% said "Yes" or "Maybe") (**Figure 3**), it also reveals a lack of knowledge on electric vehicles in general (**Figure A.1.8**). The responses to this survey question identify that more education to the public on this technology is necessary before moving forward (23% responded with "I don't know enough about these types of vehicles"). Educational initiatives can help alleviate misconceptions about range, eco-friendliness, and vehicle costs, of which a multitude of respondents of the Worthington survey identified as areas of concern. Taking cues from Columbus' Smart City goals, ride and drive events that get citizens to actively participate are a key resource to utilize. Consulting firms, such as Clean Fuels Ohio, readily partner with municipalities to run these. The Green on the Green in Worthington has featured events such as this in the past, but expanding these is crucial to enhancing electric vehicle interest. Holding ride and drives at other large events, like the Farmer's Market, or having monthly information sessions could help educate and inform citizens on EVs and increase popular acceptance. Finally, informational sessions or simply flier handouts at city meetings, sport outings, or church gatherings have been shown to be valid ways to inform the public on the benefits of electric vehicles (Greenlining Institute 2016).

## **3.4 Limitations**

There are a few limitations to the implementation of electric vehicle charging equipment. First, as noted in the survey of Worthington residents, there is a large proportion of respondents who oppose the installation of this technology (**Figure 3**). Also, there is no exact way to measure usage the Worthington station will see. While we know that the unit at the AAA in north Worthington sees roughly 20 visits per month (it is only a few months old, and expected to see increased usage with time), it is just a proxy to the traffic the commercial district unit will encounter. There is no way to exactly approximate how much increased visitation will

happen to the downtown due to adding an EVSE. As calculated earlier, Worthington will likely not see return on investment until nearly 10 years in the future. There are positive externalities, such as increased visitation to local businesses, and environmental benefits from localized electric vehicle replacement of internal combustion engines. However, these values are difficult to quantify. Finally, it must be noted that the model to calculate revenue and net present values were based on a series of assumptions with the best data available (**Table A.1.1**). There are a great multitude of variables that could change the final outcomes of these investments.

### **3.5 Further Research**

While only the single port options of both types of charging stations in the parking lot location were extrapolated on due to the highest calculated economic benefits, **Figure A.1.7** in the Appendix provides more estimates on dual port units and the library location. Further analysis can be conducted to understand to a greater degree how geographic location, number of ports, and type of model (smart or dumb), could affect consumer demand and provide the greatest overall benefit for the community of Worthington. Ohio EV Solutions was extremely helpful in gathering of information for this report, and could help answer further questions that may arise. Clean Fuels Ohio also recommended a plausible location for charging infrastructure at the Community Center, but this was out of the project scope and was not researched to any extent in this report. It was also highly suggested to look into possible funding opportunities through grants and other sources to subsidize the cost of pursuing the recommended projects, making them more economically appealing. While the window for funding is not currently open, Appendix 3 lists two sources of grants that could be applicable to Worthington's EVSE development in the near future.

## **4. Objective 2: Bike Infrastructure and Trail Signage**

### **4.1 Research Steps, Methods, and Data Collected**

Initial research involved meetings with advisors to receive any background information regarding bike programs and trail signage. A bike trip was conducted on the Olentangy Trail from Lane Avenue to Dublin-Granville Road and into Old Worthington in order to gain an understanding of the condition of the trail, and to analyze the accessibility of the historic district from the Dublin-Granville Road exit. Once a need for appropriate signage and

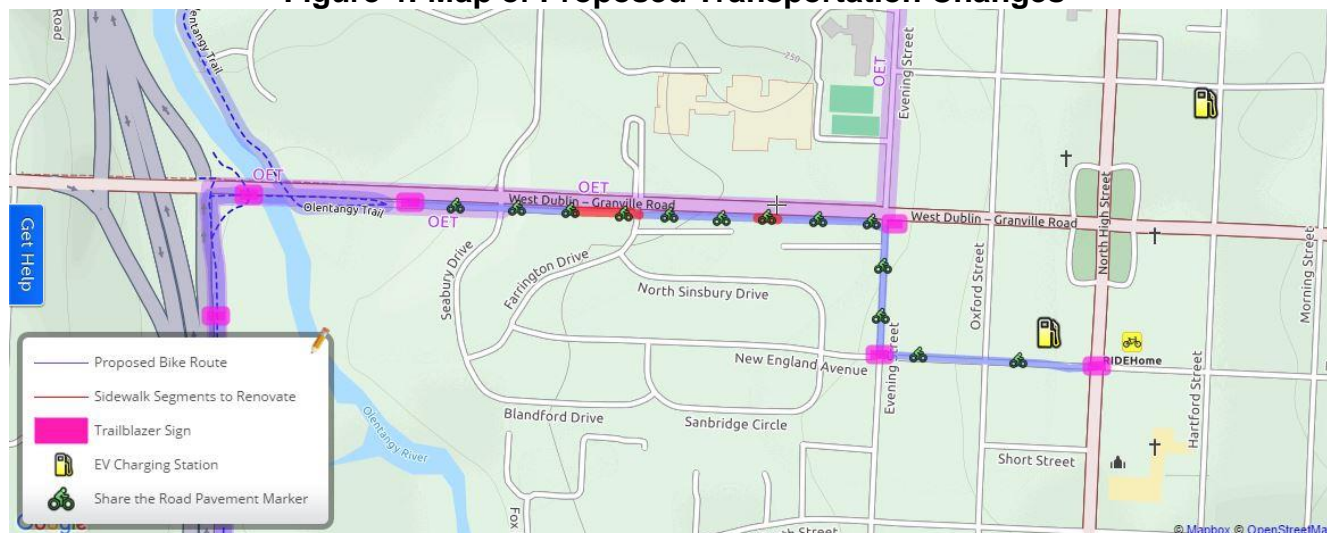
infrastructure was determined, online research was conducted using documents from the Mid-Ohio Regional Planning Commission regarding trail information and funding. A cost analysis of a trail extension done by CT Consultants and the Worthington Sustainability Initiative's summary of biking in Worthington were then reviewed. Next, a map of potential wayfinding signs and trail renovation was created to serve as a guide for cost estimation, MORPC's Traffic Count Database System was used to determine the route with the least traffic, and the Planning and Building Department was contacted for information regarding sign design and cost. Professor Jennifer Dill from Portland State University provided recommendations and research to aid in increasing and explaining bike use. Finally, the cost of the proposed trail, signs, and marking symbols were calculated based on all the collected information and additional estimates from scholarly articles.

According to the Mid-Ohio Regional Planning Commission, the Olentangy Trail, specifically the area passing Worthington, sees average daily traffic of between 817 and 1403 visitors (MORPC 2016). One in five respondents in a survey conducted of trail users reported they had or would make trail related expenditures during their visit, with an average reported expenditure of \$17.60. When aggregated across Olentangy Trail users in the Worthington area, the total amount spent daily is, on average, about \$4,000, meaning a potential influx in sales of around \$1.4 million per year (Lindsey et al. 2015). According to Heather Bowden of CoGo, "[Trails] are valuable to have in communities and a huge selling point for businesses to locate where employees have access to other modes of transportation" (City and Regional Planning Program 2007). Based on these factors, improving trail accessibility and improving wayfinding to the commercial district could improve the well-being of Worthington residents. Additionally, this could provide an economic boost to local businesses, possibly attracting new ones to the area (Lindsey et al. 2015).

## **4.2 Data Analysis and Findings**

Based on the map below created for connecting the Olentangy Trail to downtown Worthington (**Figure 4**), there are two main areas of interest regarding trail redevelopment and wayfinding. These areas are: The Olentangy Trail exit at Dublin-Granville Road to Evening Street (part one), and Evening Street to High Street (part two).

**Figure 4: Map of Proposed Transportation Changes**



Source: ScribbleMaps used to edit. Created by Luca Costa

Description: Map detailing the location of the proposed trail, pavement markings, Trailblazer signs, and EV charging stations in Worthington, Ohio.

The first, an estimated 2,483-foot stretch between the Olentangy Trail exit at Dublin-Granville Road and Evening Street, would consist of a combination bicycle trail and shared boulevard. This is recommended to include four Trailblazer signs identifying the direction towards downtown, nine pavement marking symbols placed every 250 feet indicating the shared bicycle boulevard, and contain two sidewalk segments of 298 feet, with 90 feet in need of widening, repaving, and bollards to prevent traffic from cutting through the neighborhood. According to the Mid-Ohio Regional Planning Commission (MORPC), average construction cost of a new Central Ohio Trail is around \$380,000 per mile, not including estimates of the Camp Chase Trail, I-670 Trail, and the Olentangy Trail (Lindsey et al. 2015). Using this value, the cost of construction of a new trail spanning the whole access road in question - from the end of the Olentangy Trail to Evening Street - would be \$179,000. However, many of the construction costs noted in the MORPC report come from the installation of bridges and forest paths, which do not apply to the area of interest in Worthington. Also, as most of the boulevard itself already exists, very little paving would need to be done. The majority of the costs incurred would come in the form of wayfinding signs, pavement markings, and bollards (MORPC 2016).

As mentioned, there are two stretches of sidewalk that are unsuitable to accommodate both bikers and pedestrians, both in width as well as in quality. The 298-foot sidewalk between

Seabury Drive and Farrington Drive and the 90-foot sidewalk between Farrington Drive and Evening Street would need to be redeveloped to ensure bike and pedestrian safety. The average cost of a signed bicycle boulevard is about \$239,000 per mile, according to a study conducted by the University of North Carolina, who analyzed cost averages of infrastructure and validated estimates through the Departments of Transportation in several states, including Ohio (Bushell et al. 2013). Using this value, the cost for re-pavement and widening of these two paths into bike boulevards would be \$12,667 for the 298-foot sidewalk and \$4,063 for the 90-foot sidewalk. Using the MORPC construction estimation of \$380,000 per mile, the 298-foot and 90-foot sidewalks would incur an expense of \$21,432 and \$6,460, respectively. Averaging the two studies results in estimated expenses of \$17,050 and \$5,260 for the first and second sidewalk segments, respectively (MORPC 2016). A pavement marking symbol for a shared lane/bicycle marking costs around \$180 on average, and placing one every 250 feet would result in a total cost of \$1,620 (Bushell et al. 2013). Because these sidewalks are used to inhibit motorists from cutting through the neighborhood to reach Evening Street, appropriate measures would have to be taken to ensure that the new paths serve the same purpose. One option to do so is installing bollards at each end of the two sidewalk segments. According to the UNC estimates, bollards are, on average, \$730 each. Placing three at each end of each sidewalk (twelve total) would result in a total cost of \$8,760. Based on this information, the total cost for re-paving, adding pavement markings and bollards, and expanding the two segments of sidewalk between the Olentangy Trail exit at Dublin-Granville Road and Evening Street would be around \$33,900. This data is summarized below in **Table 1**.

**Table 1: Data Calculation for Part One**

Part 1 of Trail (Exit to Evening St.)	Length (miles)	Cost of Construction of a New Trail (MORPC)		Cost of Bike Boulevard (UNC)		Cost of Pavement Bike Markers	Cost of Bollards	TOTAL
Total trail (Olentangy exit to Evening St.)	0.470	\$	178,668.37	\$	112,373.00	\$	1,620.00	\$ 8,760.00 \$ 122,753.00
298 foot Sidewalk	0.056	\$	21,446.97	\$	13,489.02	N/A	\$ 4,380.00	\$ 23,467.99
90 foot Sidewalk	0.017	\$	6,477.27	\$	4,073.86	N/A	\$ 4,380.00	\$ 11,275.57

Source: Various sources (see Appendix 1). Calculated by Luca Costa

Description: Cost calculation of widening two segments of sidewalk or repaving entire stretch from Olentangy Trail exit to Evening Street, including various improvements. Assumes nine bike markers and twelve bollards total.



The second area of interest is from the corner of Evening Street and Dublin-Granville Road to the historic district. Two potential routes for this area were proposed. The first would have continued parallel to Dublin-Granville Road and consisted of widening the existing sidewalk, installing appropriate signage, and continuing the pattern of pavement markings and bollards. This, however, was decided to be unrealistic given that the end of the trail would be passing through the Village Green. The alternative route decided upon is to lead bikers South along Evening Street and continue the trail East on New England Street. This route would imply that bikers and motorists share the road; therefore, to increase safety, it is recommended that two speed bumps be installed to slow traffic down. The total cost of four pavement markers for this segment, not including the cost of potential speed bumps, would be, according to the UNC estimates, around \$720 (Bushell et al. 2013). This data is illustrated in the **Table 2** below.

**Table 2: Data Calculation for Part Two**

Part 2 of Trail (Evening St. to Historic District)	Length (miles)	Cost of Construction (MORPC estimate)	Cost of Bike Boulevard (UNC estimate)	Cost of Pavement Bike Markers	TOTAL
Option 1: Continuation of Trail	0.189	\$ 71,969.70	\$ 45,265.15	\$ 360.00	\$ 45,625.15
Option 2: Evening- New England	0.232	N/A	N/A	\$ 720.00	\$ 720.00

Source: Various sources (see Appendix 1). Calculated by Luca Costa

Description: Cost calculation of continuing trail parallel to Dublin-Granville Road or redirecting trail South onto Evening Street and East onto New England Street, including various improvements. Assumes two and four bike markers for Options 1 and 2, respectively.

As the city has already planned a wayfinding program, costs for signage were not calculated, and location for bicycle route information and Old Worthington indicators were simply recommended. Not including costs for this signage, the estimated expenses for a total trail renovation from the Olentangy Trail exit to Evening Street, and continuing the route along Evening Street and up New England Street would be \$157,000. Widening and repaving only the two stretches of sidewalk, and continuing to the historic district along Evening Street and up New England Street would result in a total cost of \$34,000. A table summarizing both options is below (**Table 3**).

**Table 3: Data Summary of Parts 1 and 2**

Parts 1 & 2	Length (miles)	Cost of Trail Widening	Total Cost of Pavement	Total Cost of Bollards	TOTAL
Repaving Sidewalks Option	0.703	\$ 22,743.56	\$ 2,340.00	\$ 8,760.00	\$ 33,843.56
Renovating Entire Part 1 Option	0.703	\$ 145,520.69	\$ 2,340.00	\$ 8,760.00	\$ 156,620.69

Source: Tables 1 and 2 using various sources (see Appendix 1). Calculated by Luca Costa

Description: Summary of costs calculated in Tables 1 and 2 – option between repaving and widening two segments of sidewalk or repaving entire part one, then continuing South on Evening Street and East on New England Street.

## 4.3 Recommendations

There are a number of final recommendations for the City of Worthington based on the data collection, research, and analysis of improving bike infrastructure. These recommendations are as follows:

### 4.3.1 Secure Funding Through Grants

Securing additional funding from grant opportunities will help to offset the costs of the overall project. The projected cost is estimated to be around \$34,000 for trail renovation and road paint. Having funding to offset renovation and signage costs will be a big step in realizing this objective. The Recreational Trails grant offered by the Ohio Department of Natural Resources (ODNR) would be the most suitable grant for this endeavor, as it helps cities and organizations with the development of urban trail linkages, trail area restoration/maintenance, and safety education programs that are related to trails. There is up to 80 percent of matching federal funds that are reimbursed, and the deadline to apply for this grant is February 1st, 2017 (Ohio DNR 2016).

### 4.3.2 Trail Renovation

Renovation of the path leading to the commercial district would help create a better connection coming off of the trail towards Old Worthington. This path has become dilapidated and it can be difficult to realize that there is a vibrant downtown district just a few blocks away. Renovation of this area will include the addition of signs, maps, and trail re-construction so that a clear path towards Old Worthington can be available to trail users. Renovation of landscaping along this path, although not a priority, could create a warmer environment for bikers entering Worthington and act as the city's "curb appeal." Data from Portland State

University has indicated that improved trail quality can lead to increases in trail use, physical health, and mental health (Dill 2014).

#### *4.3.3 Installation of Wayfinding Signage*

Increasing signage is vital to this objective, as there is a lack of overall markings informing trail users that they are entering Worthington. Additionally, there is a lack of advertisement of Old Worthington's historic background and commercial appeal. It is recommended that signs be placed on the part of the trail that runs parallel to OH-315 to notify trail users that they have entered Worthington. An arrow indicating the location of nearby amenities, including directions to the commercial district, would also be effective. A map of the area should also be placed where the Olentangy Trail exits into Worthington, showing the safest route for bikers and pinpointing other areas of interest in Old Worthington, such as bike racks, restrooms, shops, and restaurants. Basic signs can be created "in-house" through the city's wayfinding program, and can be placed on the Olentangy Trail, as well as along the planned route to the commercial district. This would include "bikes can use full lane" signs, "share the road" pavement indicators, and route recommendations. A map detailing placement of biking information and directions can be found above (**Figure 4**).

#### *4.3.4 Biking Interest and Behavior Long Term Plan*

A long term plan regarding bike infrastructure would be useful to continue attracting bike traffic into Worthington. There has been research stating that cyclists are more comfortable riding on trails, protected bike lanes, and bike boulevards than general roads and unprotected bike lanes. Over 50% of people in a Portland study reported feeling safe when riding along a bike boulevard, compared to around 11% when riding along a residential street (Dill 2014). Bike boulevards, illustrated in **Figure A.1.9**, are separate roads specifically designated for cyclists and pedestrians, with a very small amount of through traffic. Unprotected bike lanes do not increase the feeling of safety for cyclists, with only a 1-5% increase of perceived safety compared to regular streets (Dill 2014). There is also opportunity to create a plan to increase access and interest in cycling, particularly through bike raffles at events such as Green on the Green and Market Day. Worthington has conducted bike tours in a partnership with "Yay Bikes!" in the past, and future tours highlighting proposed improvements could increase interest in biking. The City of Worthington should consider this research when planning for

bike infrastructure in the future so they can maximize the economic benefits that come from increased bike traffic.

#### **4.4 Limitations**

The biggest limitation faced with expanding bike infrastructure is balancing the costs of the recommendations against the potential benefits. The cost of sidewalk renovation, not including signage, has been estimated to be around \$34,000 using data from MORPC. The group is assuming that the cost of signage will already be budgeted for in accordance with Worthington's existing wayfinding program. Data collected at Portland State University shows that improved bike infrastructure and access to economic hubs leads to higher economic gains from increased bike traffic (Dill 2012). These gains may take some time to equate the costs associated with construction. Time was a limitation when regarding the exact measurements and renovation style for the trail. However, there seems to be sufficient information on this that can be drawn from Worthington's Bike and Pedestrian Steering Committee and their recommendations to the city.

There are also increased social, environmental, and physical health benefits from improved bike infrastructure, but these are difficult to quantify into a monetary amount. These gains would include increases in physical activity for residents in the community, as well as lower local pollution and carbon emissions, as people would potentially begin commuting via bike rather than car. Communication between collaborators was also a limitation, as there wasn't enough time to fully collaborate with as many people as expected. Another limitation is Worthington residents' desire for improved trail and biking infrastructure. The survey conducted by the capstone course has had mixed responses over biking behaviors, with a large percentage of respondents not willing to bike at all, regardless of the safety and infrastructure in place.

#### **4.5 Further Research**

In order to better tailor this project to the community, a more stringent analysis of attitudes and opinions towards biking would need to be conducted. Researching these attitudes in Worthington will help to determine the relative level of biking infrastructure that the community desires. A good resource for biking behaviors and opinions is Jennifer Dill from Portland State

University, who has been referenced throughout this objective. Surveys could also be conducted for nearby communities and even Ohio State students to measure what degree of biking infrastructure would make them more likely to visit the Old Worthington commercial district. It is encouraged that city officials take a closer look at the Bike and Pedestrian Steering Committee's recommendations regarding bike, pedestrian, and trail usage behaviors to use as a reference for this project as well as future projects (BPSC 2014). Analysis of the impact and viability of speed bumps along Evening and New England should be conducted, as they could slow motorists and create a safer cycling environment. These are all long term recommendations, but they are important to consider as Worthington continues to evolve and develop.

## **5. Bus Shelter Background, Recommendations, and Rationale**

Worthington currently has four bus stops within reasonable walking distance to downtown, with parallel stations existing on opposite corners of both the Stafford Avenue and South Street intersections with High Street. Both stations are serviced by two Central Ohio Transit Authority (COTA) bus routes: the number 2 local line and number 31 express line. All of Worthington's downtown accessible stops feature only a sign and are devoid of any sort of infrastructure or amenities such as shelters, benches, trash cans or even concrete platforms. Therefore, all Worthington stops near downtown are designated as "basic" as per COTA's station design guidelines (COTA 2012).

Originally, improvements were investigated with the intention of adding Green Roof shelters to the stops at a future date when the funds could be found or allocated to construction. Ultimately, this was removed due to the unavailability of a design firm in the central Ohio area with experience in designing and constructing such a shelter, as well as the cost of the undertaking. Additionally, the benefits of adding bus station infrastructure are mostly intangible. However, it is recommended that the City of Worthington partner with COTA in exploring options with adding at least a concrete platform at the bus stops. Such a landing pad would fulfill the Americans' with Disabilities Act guidelines for COTA bus stops and allow for wider access to buses by all citizens (COTA 2012). Fully devoting a section of this proposal to bus stations did not fit with the scope and direction of the rest of the previously discussed projects and recommendations.

## **6. Conclusion**

As a result of the above findings, it is apparent that the Old Worthington commercial district has much to gain from alternative infrastructure improvements. In conjunction with the increase in electric vehicle usage within the greater Columbus area, adding an electric vehicle charging station to the downtown area could fill the gap that exists in the EVSE network. Furthermore, the station could potentially increase through traffic of the commercial district. It would be possible for the city to recoup some or all of the cost of installation over time by charging patrons a usage fee. It is beneficial to increase public knowledge and education on the benefits of electric vehicles, based on responses to the Worthington survey. This can be achieved through outreach opportunities coupled with ride and drives at local events such as Green on the Green, Market Day, and the weekly Farmers' Market. Increased education and outreach, in addition to the availability of a public charging station, could have a positive impact on Worthington's collective emissions output and attract additional electric vehicle users to the area.

Currently, Worthington is not attracting cyclists to the commercial district via the Olentangy River Trail due to a lack of signage and confusing bike routes. These issues can be remedied through renovation of the sidewalk segments noted in previous sections, as well as adding directional and informational signage where the path becomes difficult to navigate. Funds for the improvements can be sought out through aforementioned grant opportunities, most of which involve a partnership with the federal or state level government. Further analysis of bike usage is needed to determine Worthington's long-term approach to biking infrastructure, such as adding protected bike lanes or boulevards to certain locations. Ultimately, Worthington has an opportunity to expand and improve upon its existing alternative transportation infrastructure, thus offering its citizens and visitors new ways to access and experience Old Worthington.

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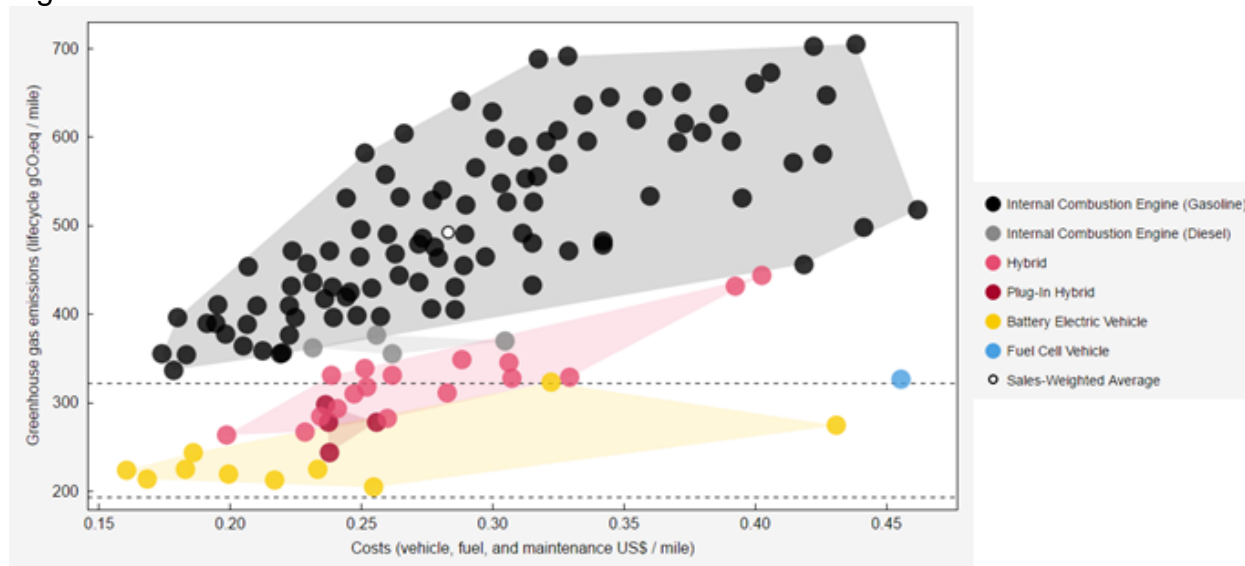
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## 8. Appendices

### 8.1 Appendix 1: Datasets and Descriptions

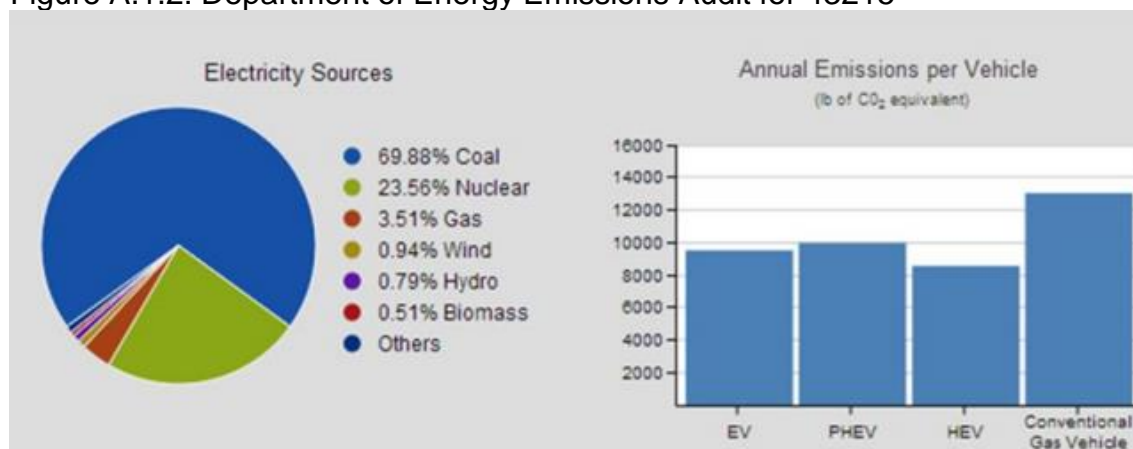
Figure A.1.1: GHG Emissions vs Lifetime Vehicle Costs



Source: MIT Carbon Counter tool; <http://carboncounter.com/>

Description: This chart plots GHG emissions against lifetime vehicle costs for over 100 popular vehicles in the United States. Electric Vehicles (Yellow) are shown most predominantly the lowest in both categories.

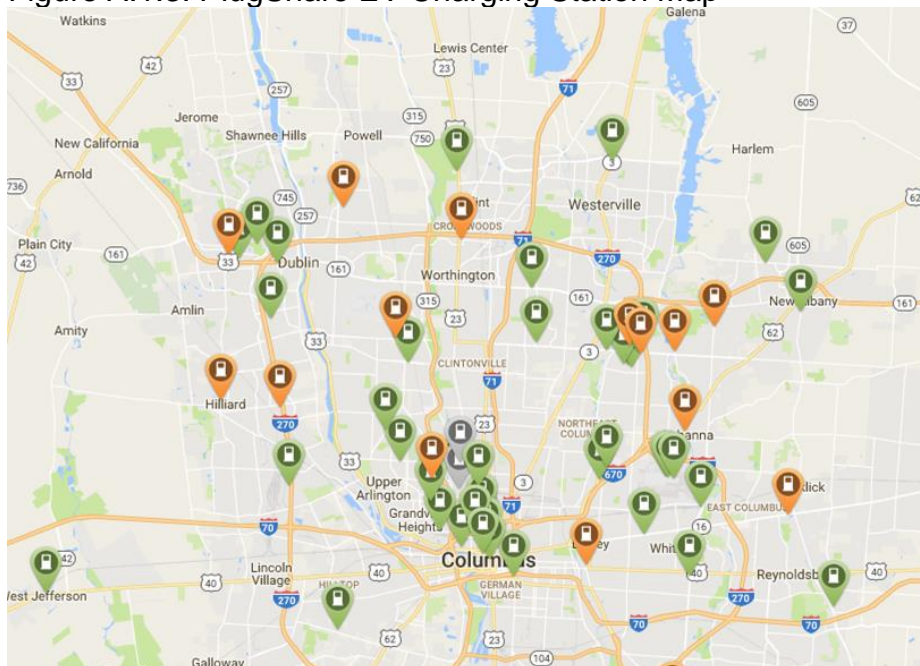
Figure A.1.2: Department of Energy Emissions Audit for 43215



Source: West Virginia University; <http://www.greenenergyohio.org/page.cfm?pageID=3605>

Description: Energy Audit with Data from the US Dept. of Energy that shows emissions from different vehicle types based on average electricity sources for the 43215 zip code.

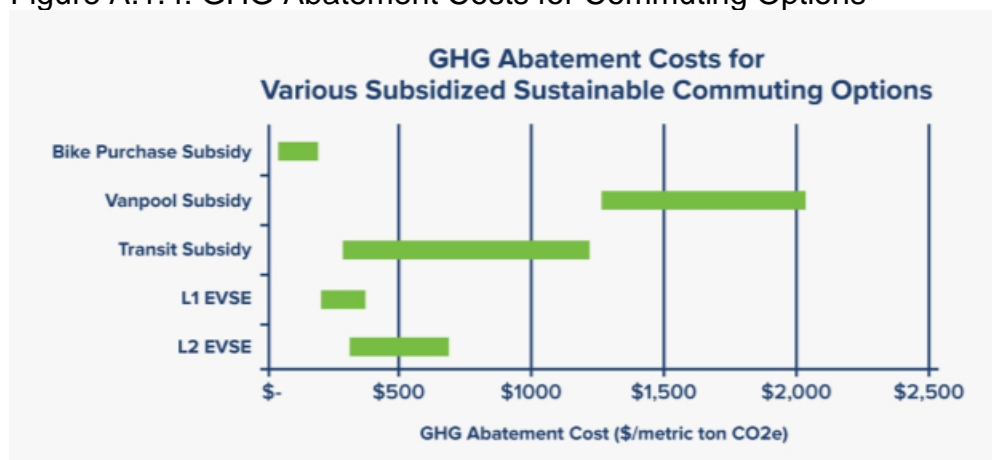
Figure A.1.3: PlugShare EV Charging Station Map



Source: PlugShare; <http://www.plugshare.com/>

Description: Tool that provides location and real time updates to all known EVSE installments in the U.S. This screen capture of the Columbus Metro region shows the “gap” in coverage where the proposed station would go in Historic Worthington. Green is level 1 and 2 while orange shows level 3.

Figure A.1.4: GHG Abatement Costs for Commuting Options



Source: U.S. Department of Energy: <http://energy.gov/eere/vehicles/greenhouse-gas-emissions-reduction-benefits-workplace-charging>

Description: Estimate of the GHG abatement cost for various alternative transportation methods. Bike and EVSE subsidies are calculated to be at the lower end of the spectrum.

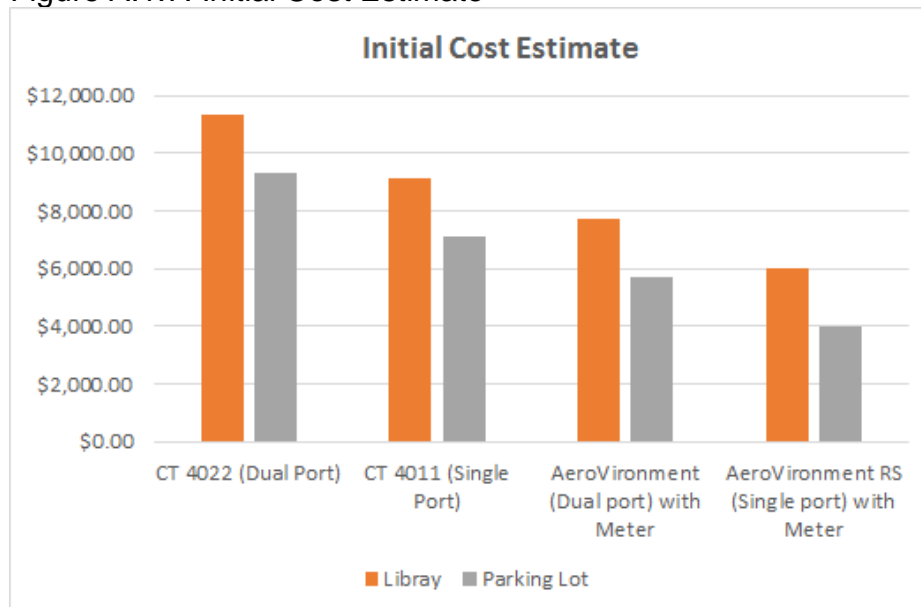
Table A.1.1: Assumptions for EVSE Net Present Value Calculation

<b>Assumption Table</b>	
Installation Cost Library	\$4,000
Installation Cost Lot	\$2,000
Price of Electricity	\$.09/kWh
Maintenance Cost	\$37.5/Year
Signage Cost	\$125.00
Maintenance Cost	\$37.5/Year
Network Cost (Smart Only)/Yr	\$240
Station Power	7 kWh
Charges/Yr	240
Average Time/Charge	2 hours
Discount Rate for NPV	5%

Source: Various sources, see Appendix 1

Description: These were the various assumptions that were made in order to calculate revenue and net present value of EVSE being installed in Worthington. A multitude of sources were used, which are referenced throughout the report in order to make the best estimate.

Figure A.1.7: Initial Cost Estimate

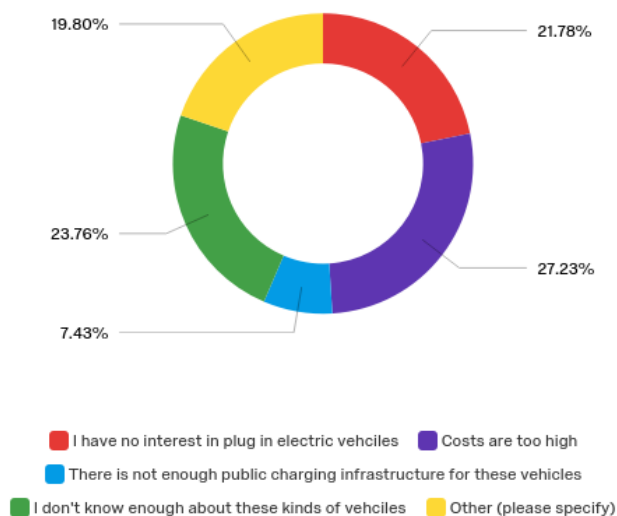


Source: Ohio EV Solutions, various EVSE retailers. Calculated by Connor Herman

Description: Total Initial cost of installation for four variations of stations. Included in calculation: installation, unit, signage and [for Aerovironment] parking meter cost.

Figure A.1.8:

Reasons for non-adoption of electric vehicles of Worthington residents.



Source: The Ohio State University ENR 4597 Qualtrics Survey

Description: The distribution of responses to the posed question from over 300 Worthington residents that participated in the online survey.

Figure A.1.9: Example of a Bike Boulevard



Source: [http://activelivingresearch.org/sites/default/files/2014\\_RethinkingStreetsTrails\\_Dill.pdf](http://activelivingresearch.org/sites/default/files/2014_RethinkingStreetsTrails_Dill.pdf)

Description: Illustration of a typical bike boulevard in Portland, Oregon

## 8.2 Appendix 2: Collaborator Meetings

Source: Jimmy Smith, Ohio E.V. Solutions. Phone: (440) 579-2350.

[www.ohioevsolutions.com](http://www.ohioevsolutions.com)

Description: Met and talked throughout semester regarding pricing and cost-benefit analysis of EV charging station installation.

Source: Lee Brown, City of Worthington Planning and Building Department. Phone: (614)

434-2424 Email: [lbrown@ci.worthington.oh.us](mailto:lbrown@ci.worthington.oh.us)

Description: Gained information about signage, pricing of trail renovations, advice on where the project should go, and anecdotes on biking behaviors in Worthington

Source: Nina Parini, Old Worthington Partnership. Phone: (614) 547-7334 Email:

[parini@oldworthingtonpartnership.com](mailto:parini@oldworthingtonpartnership.com)

Description: Conversations with Nina regarding options for trail renovation, as well as direction early on in project.

Source: Joanne Dole, Old Worthington Partnership. Email: [joschn1@gmail.com](mailto:joschn1@gmail.com)

Description: Numerous conversations and emails regarding bike signage design, EV charging infrastructure, general questions to help progress the project, and being a great source of information for Worthington resources.

Source: Brian Pratt, AAA Ohio Auto Club. Phone: (614) 431-7820 Email:

[bpratt@aaaohio.com](mailto:bpratt@aaaohio.com)

Description: Provided information on use data of Worthington AAA's EVSE.

### 8.3 Appendix 3: Notes

The terms “Old Worthington,” “historic district,” “downtown area”, and “commercial district” refer to the geographical area in Worthington, Ohio bounded by North Street, South Street, Morning Street, and Evening Street. They are used interchangeably throughout this report.

Possible future EVSE funding opportunities:

*Ohio Development Services Agency: Alternative Fuels Transportation Program:* Information on the program is forthcoming. Check in at [http://development.ohio.gov/bs/bs\\_altfueltrans.htm](http://development.ohio.gov/bs/bs_altfueltrans.htm)  
*MORPC-Attributable Funding:* Runs on a two year cycle that offers funding opportunities for various alternative transportation projects under the Surface Transportation Program, Congestion Mitigation & Air Quality Improvement Program (CMAQ) and Transportation Alternatives Program. Next cycle will be 2018. <http://www.morpc.org/transportation/funding-grants/morpc-attributable-funding/index>

EVSE station locator tools can be found at the following locations:

AFDC: <http://www.afdc.energy.gov/locator/stations/>

ChargePoint: [https://na.chargepoint.com/charge\\_point](https://na.chargepoint.com/charge_point)

PlugShare: <http://www.plugshare.com/>